

**DEQ'S COMMENTS TO: 1) NW NATURAL'S NOVEMBER 4, 2011 RESPONSES TO
THE SEPTEMBER 22, 2011 MODELING-RELATED COMMENTS ON THE REVISED
INTERIM DESIGN REPORT; AND 2) APPENDIX F OF THE REVISED
GROUNDWATER SOURCE CONTROL CONSTRUCTION DESIGN REPORT**

Comments dated July 18, 2012

NW NATURAL'S RESPONSES TO DEQ'S SEPTEMBER 22, 2011 MODELING-RELATED COMMENTS

General Comment

Transient Groundwater Modeling. NW Natural responded to DEQ's comments on the Revised Interim Design Report¹ in a letter dated November 4, 2011. Attachment B of the November 4, 2011 letter organizes NW Natural's responses into two general categories. One category (Category 1) is intended to identify DEQ comments that NW Natural understands are related to design and construction of the Alluvium water-bearing zone (WBZ) hydraulic control and containment (HC&C) system. The second category is based on NW Natural's understanding that DEQ's comments involve additional evaluations of post-construction operation and performance (Category 2). Many of the Category 1 and Category 2 responses recommend conducting "transient" groundwater modeling following construction and initial testing of the HC&C system. Transient modeling would occur during preparation of the Operations and Performance Monitoring Design Report (Operations Design Report) referenced in the Construction Design Report².

DEQ approves NW Natural proposal to conduct transient groundwater modeling after the HC&C system is constructed and tested. DEQ understands the data collected during initial testing of the full-scale HC&C system will be incorporated into the model before transient simulations proceed. Consistent with previous correspondence, DEQ expects transient simulations to verify the MODFLOW model's ability to simulate groundwater flux and hydraulic head conditions resulting from seasonal changes in groundwater recharge, river stage, and fluctuating tidal conditions. DEQ anticipates transient modeling will include, but not necessarily be limited to; verifying the MODFLOW model using data collected during the Segment 2 extraction well pilot test(s) and the hydraulic control and containment (HC&C) system shake-down tests.

Category 1, Comment 2, 1st bullet page 7 (also Category 2, Comment 1). DEQ believes this comment is addressed under the Framework for finalizing the design and constructing the Alluvium WBZ HC&C system. Simulations of the HC&C system under seasonal extremes will be completed prior to finalizing the designs of the remaining extraction wells in the HC&C system (i.e., prior to initiation of construction). This modeling work will not be postponed until preparation of the Operations Design Report.

¹ Anchor QEA, LLC, 2011, "Draft Groundwater Source Control Final Design Report, NW Natural Gasco Site," May (received May 9th), a report prepared on behalf of NW Natural (recognized being the equivalent of the Revised Groundwater Source Control Interim Design Report).

² Anchor QEA, LLC, "Revised Groundwater Source Control Construction Design Report, NW Natural Gasco Site," January 2012 (received January 31st), a report prepared for NW Natural.

Two scenarios encompass the seasonal extremes needed to assess long-term operation and performance of the HC&C system, including conditions of river stage and groundwater levels which would:

- Maximize groundwater flux through the Alluvium WBZ; and
- Minimize available drawdown to the upper Alluvium WBZ extraction wells.

For clarification, DEQ considers simulations using March 27, 2000 water level data to be acceptable for: 1) assessing the potential maximum seasonal groundwater flux through the Alluvium WBZ; and 2) estimating the maximum treatment system inflow rates. These simulations were completed during treatment system design and used in part to size system components. Modeling of the minimum available drawdown scenario for the upper Alluvium WBZ extraction wells will be completed consistent with the Framework as a final design evaluation step.

Category 1, Comment 2, 1st full paragraph page 8 (also Category 2, Comment 2). DEQ's general comment regarding transient modeling applies here.

Category 1, Comment 15, Section 3.2.1.4 (also Category 2, Comments 7 and 8). DEQ replies to NW Natural's responses are provided below.

1st bullet. Given NW Natural's deletion of the requested paragraph, DEQ considers this comment to be addressed.

2nd bullet. As indicated above, the Framework addresses this comment. Simulations of the seasonal conditions which would minimize available drawdown for the upper Alluvium WBZ extraction wells will be completed during extraction well final design.

3rd bullet. On behalf of NW Natural, Anchor submitted a supplement to Appendix F of the Construction Design Report titled, "NW Natural Gasco Site: Documentation of Groundwater Model Modifications Since 2008" dated April 12, 2012 (April 12th Memorandum) to address this comment. DEQ's comments on the April 12th Memorandum are provided below in a separate section of this letter.

4th bullet. NW Natural responds to this comment by including a water budget in the Construction Design Report (see Figure 3-4) that is based on the MODFLOW model. However, there does not appear to any information provided in the Construction Design Report to document the source(s) of values shown in Figure 3-4. NW Natural should explain the basis for the water budget and each of the component values shown.

5th bullet. DEQ accepts Figure 3-4 as responding to our request for information regarding the estimated extraction rates for the upper and lower Alluvium WBZ extraction well groups. Under the assumption of a reasonable worst-case maximum seasonal groundwater flux through the Alluvium WBZ, DEQ understands the upper and lower Alluvium WBZ well groups are estimated to extract 50 gpm and 210 gpm respectively.

NW Natural did not provide information on whether the lateral and vertical extent of the capture zone produced by operating the HC&C system during conditions of maximum groundwater flux are anticipated to be the seasonal minimum, average, or maximum. DEQ requests the lateral and vertical extent of capture zones produced by operating the HC&C system under the two seasonal extreme scenarios (i.e., maximum groundwater flux, minimum available drawdown) be considered, compared, and discussed during final design of the remaining extraction wells.

6th bullet. DEQ's comment requested additional information regarding the following:

1. Figures depicting the captures zone(s) for the HC&C system with depth;
2. Cross-sectional views of capture zones through extraction wells PW-2, PW-6, and PW-9; and
3. The times after start-up the intermediate and final capture zones represent.

NW Natural's responses to items #1 and #2 are acceptable to DEQ. For Item #1 NW Natural includes figures 3-2.a through 3-2.e in the Construction Design Report to illustrate capture zones in the Alluvium WBZ at the depth intervals requested by DEQ. In response to DEQ's request for Item #2, NW Natural provides a figure with particle tracks to illustrate vertical capture along a cross-section through extraction well PW-5 along with an explanation of why the cross-sections DEQ requested were not produced.

Information for Item #3 is not provided in the Construction Design Report and should be provided when the final design modeling scenario is completed.

Regarding figures 3-2.a through 3-2.e, given the figures illustrate the results of simulations for the Alluvium WBZ, DEQ understands the contraction and/or loss of the capture zones associated with extraction wells PW-9-92 and PW-10L are due to the shallower occurrence of the basalt in this portion of the site. However, the reason(s) for the expansion of the PW-01U,L and PW-02U,L capture zones out under the river, and the associated irregular particle tracks should be further explained (see especially figures 3-2.c through 3-2.d). This information should be provided when the final design modeling scenario is completed.

7th bullet. DEQ's comments regarding the hydraulic properties of the Fill WBZ related to the MODFLOW model are included below with those provided for the April 12th Memorandum.

Category 1, Comment 15, last paragraph (also Category 2, Comment 9). DEQ's general comment regarding transient modeling applies here.

Category 1, Comment 16, Section 3.2.1.5. NW Natural responds to DEQ's comment by indicating figures 3-5.a and 3-5.b (formerly figures 3-3.a and 3-3.b) are drawn through extraction wells PW-13, and PW-4U and PW-4L respectively. NW Natural's response is acceptable to DEQ.

Category 1, Comment 17, Section 3.1.9. NW Natural responds to DEQ's comment requesting documentation of the updates made to the MODFLOW model by submitting the April 12th Memorandum. DEQ's comments on the April 12th Memorandum are provided below in a separate section of this letter.

NW Natural also informs DEQ that if water levels in the Alluvium WBZ are predicted to occur below the bottom of the upper silt unit, the model calculates transmissivity based on saturated thickness and the storage coefficient for the unconfined condition is used. NW Natural response is acceptable to DEQ.

Category 1, Comment 18, Section 3.2.2.2.1, 1st paragraph page 29 (also Category 2, Comment 10). As indicated above, the Framework addresses this comment. Simulations of the seasonal extremes of river stage and groundwater levels which would minimize available drawdown for the upper Alluvium WBZ extraction wells will be completed as part of completing the final extraction wells design of evaluating the long-term operations and performance of the HC&C system design. The design of the upper Alluvium WBZ extraction wells, including pump placement; will be considered in the context of these simulations.

Category 1, Comment 19, Section 3.2.2.2.1, 1st paragraph page 30. DEQ considers NW Natural's response to our comments to be acceptable. NW Natural confirms DEQ's understandings of the modeling scenario used to produce capture zone figures 3-2.a through 3-2.e in Section 3.1.4 of the Construction Design Report, and provides documentation of changes made to the model in the April 12th Memorandum.

Category 1, Comment 20, Section 3.2.2.5.2, 1st paragraph. DEQ accepts the April 12th Memorandum as responding to our comment regarding the current status of the MODFLOW model. DEQ's comments on the April 12th Memorandum are provided below in a separate section of this letter.

Category 1, Comment 20, Section 3.2.2.5.2, 6th and 7th paragraphs (also Category 1, Comment 4, 5th bullet page 11 and Category 2, Comments 4, 5, 12). DEQ does not accept NW Natural's response to this comment. The ΔH value is a critical design parameter for the HC&C system as it controls the magnitude of the hydraulic gradient between the river and the HC&C control wells. From the standpoint of HC&C system operation, the delta value must be equaled or exceeded at control wells on an average basis for the HC&C system to be effective. DEQ understands NW Natural's recommendation to provide ΔH values during the startup process postpones evaluation of this important design parameter until after the HC&C system is fully constructed. This proposal is not approved by DEQ.

DEQ believes evaluation of ΔH values should occur before the HC&C system is constructed. However, DEQ also acknowledges NW Natural's assertion that the selection of ΔH values for operation of the HC&C system should be based on the data from full-scale testing. In general, DEQ's believes the selection of operational parameters (e.g., limits on extraction well pumping rates) and performance criteria (e.g., ranges of horizontal and vertical gradients expected to minimize potential DNAPL movement) will benefit from full-scale testing of the HC&C system. That said, NW Natural's reasons for not providing estimated ΔH values (or a range of values) as projected performance criteria which will be refined during HC&C system shake-down testing are unclear to DEQ. DEQ believes this topic warrants additional discussions, including NW Natural's proposed approach for evaluating and selecting ΔH values, as well as other operational parameters and performance criteria. Besides ΔH values at control wells, DEQ requests NW Natural provide additional information about the criteria that will be used to determine hydraulic

control and containment is being achieved at monitoring wells and piezometers in the performance monitoring program (i.e., at installations other than control wells).

DEQ's comment also requests NW Natural to provide information as to how factors unrelated to operation of the extraction wells will be accounted for in selecting ΔH values. As indicated in DEQ's general comments to the Revised Interim Design Report, NW Natural's presumption that during Segment 2 pilot well tests groundwater level changes and gradient changes observed between pre-pumping and pumping periods were due entirely to the influence of extraction wells could lead to overestimating the effectiveness of the HC&C. DEQ requests NW Natural to provide additional information on how factors such as river stage and tidal fluctuations will be incorporated into evaluations and selection of ΔH values.

CONSTRUCTION DESIGN REPORT, APPENDIX F

DEQ reviewed model documents contained in Appendix F of the Construction Design Report. In response to DEQ's comments on the Revised Interim Design Report, NW Natural submitted the April 12th Memorandum as a supplement to Appendix F. As requested by DEQ in our comments to Section 3.1.9 of the Revised Interim Design Report, the April 12th Memorandum provides additional documentation of the MODFLOW model.

DEQ's comments on Appendix F are provided below.

General Comment

Modeling documentation lacks consistency and presumes there is a general understanding about the model, model development, model parameters, and uses of the model. This is not the case. DEQ is aware of many versions of the MODFLOW model which have been, or are being used to simulate specific scenarios and/or conditions. It is not clear to DEQ which version of the model is being used to assess the scenarios and site conditions described in the April 12th Memorandum. For example, are site paving and the interceptor trench now included in the working version of the model?

To reduce the potential for misunderstandings and/or miscommunications, DEQ believes it is important for NW Natural to identify which version of the MODFLOW model is being used as the baseline model for the site. If a baseline model is not being used, then NW Natural and DEQ need to establish a method for identifying which version of the model is being used to assess a specific set of site scenarios or conditions. DEQ considers this to be important given the model will be modified further based on the results of recently completed step-drawdown testing, and later by the results of the HC&C system shake-down test(s).

Expansion of the Groundwater Model. The April 12th Memorandum indicates the northwest boundary of the MODFLOW model encompasses the U.S. Moorings site "small boat basin." DEQ approves the expansion for the reasons cited in the memorandum.

For clarification, DEQ requests the scope of any planned future evaluations of the interceptor trench to include the section along the northern property line between the Gasco Site and the U.S. Moorings Site. DEQ also requests the MODFLOW model be used to support of this work.

Model Grid Refinement. DEQ's general comment about using the MODFLOW model to evaluate site scenarios or conditions applies to the information provided here regarding additional evaluations of the upland hydraulic conductivity (K) assignments. Furthermore, the written descriptive documentation provided in the April 12th Memorandum is inadequate for DEQ to review and/or comment on use of the model for the purpose described.

That said, DEQ approves NW Natural's change to the overall grid spacing of the model from a grid of 40-feet by 40-feet to 20-feet by 20-feet. Although, NW Natural considers the change in grid spacing to be unnecessary for designing the HC&C system, DEQ believes the modification could provide additional resolution of the distribution of heads and gradient changes during simulations of the seasonal conditions which would minimize available drawdown, and for purposes of modeling the influence of the interceptor trench on the Fill WBZ and transient modeling of the HC&C system.

DEQ notes NW Natural's comment regarding the poor calibration of the model to uplands water levels. NW Natural attributes the under-prediction of water levels at uplands monitoring wells MW-10-61, MW-14-110, and MW-15-66 to the extension of the "intermediate high K zone" on water levels in the uplands. The potential influence of extending the "intermediate high K zone" on water levels in the uplands is assessed in the April 12th Memorandum by reducing the K value to 5 feet/day which reportedly results in better calibration. DEQ notes the comparison of calibration results between the "Interim Design Model" and the "Construction Design Model" shown in Figure 2 would be more informative if the data points were labeled.

DEQ currently understands hydraulic conductivity assignments in the current version of the MODFLOW model are consistent with the table nested in Section 3.1.4 of the Construction Design Report. The phase "intermediate high K zone" does not appear in the table. DEQ understands from the last section of the April 12th Memorandum ("Simulation of the Variable Rate Pumping Test") the "intermediate alluvium K" was reduced to 5 feet/day from 300 feet/day (i.e., the value referenced for the "Lower Alluvium above Aquitard"). However, this appears to contradict hydraulic conductivity assignments used in the model. The bottom elevation of the three referenced monitoring wells are above or near elevation -70 feet, which is the elevation of the contact between the "Upper Alluvium" and "Lower Alluvium above Aquitard" used for modeling purposes. In other words, the model assigns a hydraulic conductivity to the "Upper Alluvium" (the material in which the wells are completed) of 10 feet/day, not 300 feet/day (the value assigned to the "Lower Alluvium above Aquitard").

Given the inconsistency in nomenclature used and lack of specificity in the description of the work done, it is difficult to understand NW Natural's comment and/or the work done to further assess the influence of alluvium K values on uplands water levels.

Refinement of Shallow Alluvium Hydraulic Conductivity. On behalf of NW Natural, Anchor is putting together a data package documenting recently completed redevelopment work and

step-drawdown testing at most of the upper Alluvium WBZ extraction wells. DEQ understands from telephone and meeting discussions, redevelopment measurably increased the specific capacities and well efficiencies of extraction wells PW-2U, PW-3U, PW-5U, PW-6U, PW-8-38, and PW-9-92. DEQ further understands the results of the post-redevelopment step-drawdown tests are currently being incorporated into the MODFLOW model. Consequently, DEQ will wait to provide comments on refinements made to the shallow Alluvium WBZ K values and the model after reviewing the redevelopment/step-drawdown data package.

DEQ notes that NW Natural appears to be focusing efforts to update the MODFLOW model on the Alluvium WBZ. It is less clear whether additional data for the Fill WBZ and the upper silt aquitard is also being considered. Siltronic conducted variable head tests along the shoreline, the results of which indicate the horizontal K value of the Fill WBZ ranges between 11 feet/day and 61 feet/day (geometric mean ~ 23 feet/day). In addition, vertical permeability tests were conducted on samples from the upper silt unit collected during the remedial investigation of MGP contamination on the Siltronic property. The vertical K values base on these tests range between 0.002 feet/day and 0.004 feet/day (geometric mean ~ 0.002 feet/day). For comparison, the horizontal K value for the Fill WBZ and the vertical K value for the upper silt unit being used in the model are 10 feet/day and 0.005 feet/day respectively. DEQ requests the input parameters for the Fill WBZ and silt unit in the MODFLOW model make use of this information.

Deep Aquitard. DEQ preliminarily accepts NW Natural's conceptual model for the influence of the deep aquitard on the movement of groundwater in the deep Alluvium WBZ zone. NW Natural proposes that due to the nature of the alluvium and the gradients caused by the HC&C system compared to the river, groundwater in the deep Alluvium WBZ (i.e., groundwater below the deep aquitard) will be drawn to extraction wells. Consistent with DEQ's December 7, 2011 letter commenting on the proposed Framework, the conceptual model will be demonstrated using field data collected from existing monitoring wells and additional installations constructed for this purpose.

DEQ also notes the need for information requested previously regarding NW Natural's identification of the deep aquitard. As indicated in the Interim Design Report, NW Natural relied on observations made during drilling of shoreline monitoring wells and Targost® logs to develop interpretations of the depth, thickness, and lateral extent alluvial sediments, including the deeper aquitard. Stratigraphic interpretations involving Targost® borings were actually based on data generated by the cone-penetrometer tool (CPT). DEQ understands that prior to use on the NW Natural property, the Targost® probe and CPT were advanced adjacent to previously drilled and visually logged borings for comparison and correlation purposes. To date, NW Natural has not provided documentation of the work done to correlate Targost®, CPT, and boring logs. In addition, NW Natural has not showed how the correlation between the CPT and boring logs was used to identify the deep aquitard at Targost®/CPT boring locations. DEQ continues to request this information for purposes of documenting deep aquitard interpretations and for completeness.

Additional Design Features. DEQ's general comment about using the MODFLOW to evaluate site scenarios or conditions applies here. Furthermore, the written descriptive documentation

provided in the April 12th Memorandum is inadequate for DEQ to review and/or comment on use of the model for the purposes described.

DEQ understands NW Natural added paving and the interceptor trench to the model in response to comments received on the Revised Interim Design Report. For clarification and pending confirmation from NW Natural on how modeling was done, DEQ considers these features to be temporary additions to the MODFLOW model which are appropriate for assessing certain site scenarios. In other words, they should not be retained as permanent features in the MODFLOW model. That said, paving and the trench may be appropriate for simulations of seasonal extremes of river stage and groundwater levels which would minimize available drawdown.

Simulation of Variable Rate Pumping Test. DEQ's general comment about the version(s) of the MODFLOW model being used to evaluate site scenarios or conditions applies here. Furthermore, the written descriptive documentation provided in the April 12th Memorandum is inadequate for DEQ to review and/or comment on use of the model for the purposes described. DEQ understands the results of the post-redevelopment step-drawdown tests are being incorporated into the MODFLOW model. Consequently, the information provided here may change. DEQ will wait to provide comments on refinements made to the shallow Alluvium WBZ K values and the model after reviewing the redevelopment/step-drawdown data package.